

Appl. No. 10/069,031
Amdt. dated July 1, 2005
Reply to Office Action of June 04/07/2005

REMARKS/ARGUMENTS

In the Office Action, the Examiner presumes correctly that the subject matter of the various claims was commonly owned at the time of the invention by all the joint inventors.

Claims 40-47, 49, 50-52, 54, 56-57, 60-63 were rejected under 35 USC 103(a) as unpatentable over Crawley et al (US 5,871,586) in view of Burk (US 5,788,777) on the grounds set forth in the Office Action.

Claims 48, 55, 58-59, 64-66 were rejected under 35 USC 103(a) as unpatentable over Crawley et al in view of Burk as applied to claims 40-47, 49, 50-52, 54, 56-57, 60-63, and further in view of Flynn et al (US 6,447,604) for the reasons stated in the Office Action.

Claim 53 was rejected under 35 USC 103(a) as unpatentable over Crawley et al in view of Burk as applied to claims 40-47, 49, 50-52, 54, 56-57, 60-63, and further in view of Hirata et al (US 4,542,273) on the grounds set forth in the Office Action.

By this response with respect to the rejections under 35 USC 103, the claims are believed to be distinguishable from the teachings of the cited art in view of the following argument.

1. The reactor of the invention is a flow channel reactor. It is heated on all sides. (The substrate holder must be on a high temperature and the ceiling of the process chamber must be on high temperature.) The gas stream flows in a horizontal direction. The inlet area of the gas into the process chamber is actively cooled down to very low temperature (20°C to 40°C). The process chamber itself contains a substrate holder which is actively heated and a ceiling above the substrate holder which is actively heated as well.

The independent claims 40 and 46 are amended to specifically set forth the foregoing features. Dependent claims have been amended for clarity, and to conform to the amendments of the independent claims.

As a consequence of these features there is a very low temperature gradient vertically above the substrate. The temperature above the substrate holder differs only about a few degrees. This low temperature gradient is necessary to avoid silicon-cluster generation.

The active cooling of the gases before horizontally entering the process chamber causes a strong gradient in the horizontal (radial) direction. The gases which leave this

cool entrance zone are heated very rapidly to process temperatures. This rapid heating avoids pre-reactions of the process gases and the formation of silicon clusters. In figures 1 to 4 of the present invention one can see strong horizontal gradient of temperature between the cooled inlet area and the heated process chamber.

In the process (reactor) chamber itself, all walls have temperatures above the silicon-melting temperature. So no limitation in the growth rate occurs. It is possible to control the Si/C ratio and the doping of the material.

2. Crawley discloses a reactor with a shower head type gas inlet. This shower-head gas inlet is actively cooled but it is located vertically above the heated substrate holder. Crawley does not disclose a flow-channel reactor. The reactor is not heated on all sides. Crawley discloses a reactor which has only one side (substrate holder) which is heated and one side which is cooled (ceiling).
3. If one combines the Crawley reactor with the Burk assembly one gets a reactor with a very strong vertical temperature gradient. This is exactly the opposite of what the present invention claims call for. According to the invention the temperature gradient in vertical direction is very low (the reactor is heated on all sides). The precursors (hydrocarbons) would have to be transported against a vertical temperature gradient. This vertical transport against a temperature gradient leads to the formation of a

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silicon cluster in a region of the process chamber above the substrate. As a result of this Si cluster, forming the growth rate is limited to 4 - 5 microns per hour. Only a very limited control of the Si/C ratio is possible. The control of doping is difficult.

If one were to imagine a possible combination of Crawley and Burk, in the reactor, in the middle region between the showerhead inlet area (ceiling) which is cooled down to nearly room temperature and the strong-heated substrate, the generation of Si clusters occurs at a temperature of about 1.410°C.

4. Experiments have shown that the crystal quality of material grown with the claimed process is much higher than the crystal quality of material grown by procedures of the state of the art.

Accordingly this argument is believed to overcome the rejections under 35 USC 103 so as to secure allowance of the claims.

In the event there are further issues remaining in any respect the Examiner is respectfully requested to telephone attorney to reach agreement to expedite issuance of this application.

Applicants respectfully request that a timely Notice of Allowance be issued in this case.

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Since the present claims set forth the present invention patentably and distinctly, and are not taught by the cited art either taken alone or in combination, this amendment is believed to place this case in condition for allowance and the Examiner is respectfully requested to reconsider the matter, enter this amendment, and to allow all of the claims in this case.

Respectfully submitted,
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by: 
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CERTIFICATE OF FACSIMILE TRANSMISSION

I hereby certify that the Amendment Upon Final Rejection is being facsimile transmitted to the Patent Office on July 1, 2005.


Signed by Martin A. Farber

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